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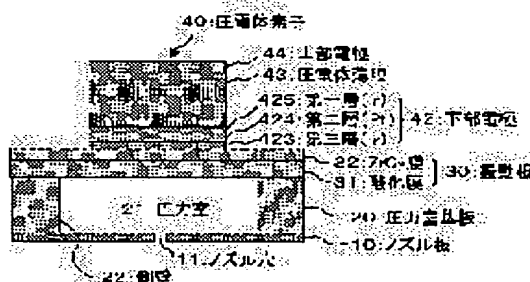
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(54) PIEZOELECTRIC ELEMENT, MANUFACTURING METHOD THEREFOR, INK JET RECORDING HEAD, AND PRINTER

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a piezoelectrics element having stable high piezoelectric characteristics, an ink jet recording head, and a printer.

SOLUTION: There are sequentially laminated a lower electrode 42 (a third layer 423 comprising Ir, a second layer 424 comprising Pt, and a first layer 425 comprising Ir), a Ti layer of 4-6 nm, a piezoelectrics thin film 43, and an upper electrode 44, on a ZrO₂ film 32. A 100 plane orientation degree of the piezoelectrics 43 measured by an X-ray diffraction wide angle method is 40-70%, a 110 plane orientation degree of it 10% or less, and a remaining 111 plane orientation degree. Here, the thickness of the lower electrode second layer 424 is 30-50% of the entire thickness of lower electrode 42.



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CLAIMS

[Claim(s)]

[Claim 1] It is the piezo electric crystal component to which it is the piezo electric crystal component equipped with the lower electrode formed on ZrO₂ film, the piezo electric crystal film formed on this lower electrode, and the up electrode formed on this piezo electric crystal film, and is characterized by the 100th page amount of preferred orientation which measured said piezo electric crystal film by the X diffraction wide angle method being 70% or less 40% or more.

[Claim 2] It is the piezo electric crystal component which is a piezo electric crystal component according to claim 1, and is characterized by for the 110th page amount of preferred orientation which measured said piezo electric crystal film by the X diffraction wide angle method being 10% or less, and the 111st page amount of preferred orientation being the remainder.

[Claim 3] It is a piezo electric crystal component according to claim 1. Said lower electrode It has at least the first pass which is located in the maximum upper layer and contains Ir, and the second layer which is located in the following layer and contains Pt, and — this — the piezo electric crystal component characterized by for the thickness of the second layer being 50% or less, having formed with a 4nm or more thickness [6nm or less] Ti layer on said lower electrode 30% or more to the thickness of the whole lower electrode, and forming the piezo electric crystal film on this Ti layer.

[Claim 4] It is the piezo electric crystal component characterized by being a piezo electric crystal component according to claim 3, and equipping said lower electrode with the third layer which is said layer [second] following layer, is located in the lowest layer of said lower electrode, and contains Ir.

[Claim 5] The piezo electric crystal component characterized by being a piezo electric crystal component according to claim 3, and said second layer which contains Pt among said lower electrodes being the lowest layer.

[Claim 6] It is a piezo electric crystal component according to claim 1. Said lower electrode It has at least the first pass which is located in the maximum upper layer and contains Pt, and the second layer which is located in the following layer and contains Ir. And the piezo electric crystal component characterized by for the thickness of this first pass being 40% or less, having formed with a 4nm or more thickness [6nm or less] Ti layer on said lower electrode 20% or more to the thickness of the whole lower electrode, and forming the piezo electric crystal film on this Ti layer.

[Claim 7] The piezo electric crystal component characterized by being a piezo electric crystal component according to claim 6, and said second layer which contains Ir among said lower electrodes being the lowest layer.

[Claim 8] The ink jet type recording head characterized by preparing the piezo electric crystal component according to claim 1 to 7 as an electrostrictive actuator on the diaphragm which is the installation side of this piezo electric crystal component.

[Claim 9] The printer characterized by having the ink jet type recording head according to claim 8 as a printing means.

[Claim 10] The process which forms ZrO₂ film on a substrate, and the process which forms a lower electrode on this ZrO₂ film, The process which forms with a 4nm or more thickness [6nm or less] Ti layer on this lower electrode, It is the manufacture approach of a piezo electric crystal

component equipped with the process which forms the piezo electric crystal precursor film on this Ti layer, and a baking process. Said lower electrode It has at least the first pass which is located in the maximum upper layer and contains Ir, and the second layer which is located in the following layer and contains Pt, and — this — the process in which the thickness of the second layer is 50% or less, and forms said lower electrode 30% or more to the thickness of the whole lower electrode The manufacture approach of the piezo electric crystal component characterized by what it has for the process which forms said second layer containing Pt, and the process which forms said first pass containing Ir on this second layer at least.

[Claim 11] The process which forms ZrO₂ film on a substrate, and the process which forms a lower electrode on this ZrO₂ film, The process which forms with a 4nm or more thickness [6nm or less] Ti layer on this lower electrode, It is the manufacture approach of a piezo electric crystal component equipped with the process which forms the piezo electric crystal precursor film on this Ti layer, and a baking process. Said lower electrode It has at least the first pass which is located in the maximum upper layer and contains Pt, and the second layer which is located in the following layer and contains Ir. And the process in which the thickness of this first pass is 40% or less, and forms said lower electrode 20% or more to the thickness of the whole lower electrode The manufacture approach of the piezo electric crystal component characterized by what it has for the process which forms said second layer containing Ir, and the process which forms said first pass containing Pt on this second layer at least.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] When this invention relates to the piezo electric crystal component which has an electric machine conversion function and is especially used for an ink jet type recording head, it relates to the manufacture approach of the piezo electric crystal component from which the outstanding piezo-electric property is acquired, an ink jet type recording head, a printer, and a piezo electric crystal component.

[0002]

[Description of the Prior Art] A piezo electric crystal component is used for an ink jet type recording head as a driving source of the ink regurgitation of a printer. Generally this piezo electric crystal component is equipped with a piezo electric crystal thin film, the up electrode arranged on both sides of this, and a lower electrode, and is constituted.

[0003] The piezo electric crystal component which aimed at the property improvement is developed by specifying conventionally the crystal structure of the thin film which consists of PZT (PZT), or making Ti nucleus form on a lower electrode. For example, the PZT thin film which equipped JP,10-81016,A with the crystal structure of a rhombohedral system, and equipped it with the predetermined amount of preferred orientation is indicated. Moreover, the piezo electric crystal component in which the titanium nucleus was formed on the lower electrode of Ir is indicated by JP,8-335676,A.

[0004] However, with the conventional piezo electric crystal component, there was a problem that it was difficult to be stabilized and to obtain the predetermined amount of preferred orientation of a piezo electric crystal thin film with sufficient repeatability. It is difficult for such a piezo electric crystal component to acquire the stable piezo-electric high property, and it has become the factor which cannot fully obtain an ink jet type recording head or the printing engine performance of a printer.

[0005]

[Problem(s) to be Solved by the Invention] The object of this invention is by canceling the above-mentioned trouble, being stabilized and obtaining the predetermined amount of preferred orientation of a piezo electric crystal thin film with sufficient repeatability to provide the ink JIETO type recording head using a piezo electric crystal component and this equipped with the stable piezo-electric high property, and a printer list with the manufacture approach of a piezo electric crystal component.

[0006]

[Means for Solving the Problem] The piezo electric crystal component of this invention is a piezo electric crystal component equipped with the lower electrode formed on ZrO₂ film, the piezo electric crystal film formed on this lower electrode, and the up electrode formed on this piezo electric crystal film, and the 100th page amount of preferred orientation which measured said piezo electric crystal film by the X diffraction wide angle method is characterized by being 70% or less 40% or more.

[0007] Moreover, it is desirable that the 110th page amount of preferred orientation is 10% or less, and the 111st page amount of preferred orientation is the remainder.

[0008] the first pass which said especially lower electrode is located in ** maximum upper layer, and contains Ir, and the second layer which is located in the following layer and contains Pt — at least — having — and — this — to the thickness of the whole lower electrode, the thickness of the second layer is 50% or less, forms with a 4nm or more thickness [6nm or less] Ti layer on said lower electrode 30% or more, and forms the piezo electric crystal film on this Ti layer. **—1 [moreover,] — the third layer which is said layer [second] following layer, is located in the lowest layer of said lower electrode, and contains Ir — having — **** — **—2 — said second layer which contains Pt among said lower electrodes may be the lowest layer.

[0009] Moreover, said lower electrode is equipped with the first pass which is located in ** maximum upper layer and contains Pt, and the second layer which is located in the following layer and contains Ir at least. And it is characterized by for the thickness of this first pass being 40% or less, having formed the layer of with a 4nm or more thickness [6nm or less] Ti nucleus on said lower electrode 20% or more, to the thickness of the whole lower electrode, and forming the piezo electric crystal film on this Ti layer. **—1 [moreover,] — said second layer which contains Ir among said lower electrodes may be the lowest layer.

[0010] Moreover, this invention is an ink jet type recording head characterized by being prepared as an electrostrictive actuator on the diaphragm whose above-mentioned piezo electric crystal component is an installation side.

[0011] Moreover, this invention is a printer characterized by having this ink jet type recording head as a printing means.

[0012] Furthermore, the process at which this invention forms ZrO₂ film on a substrate and the process which forms a lower electrode on this ZrO₂ film, The process which forms the layer of with a 4nm or more thickness [6nm or less] Ti nucleus on this lower electrode, It is the manufacture approach of a piezo electric crystal component equipped with the process which forms the piezo electric crystal precursor film on this Ti layer, and a baking process. The ** aforementioned lower electrode It has at least the first pass which is located in the maximum upper layer and contains Ir, and the second layer which is located in the following layer and contains Pt. and — this — the process in which the thickness of the second layer is 50% or less, and forms said lower electrode 30% or more to the thickness of the whole lower electrode [whether it has at least the process which forms said second layer containing Pt, and the process which forms said first pass containing Ir on this second layer, and] Or the ** aforementioned lower electrode is equipped with the first pass which is located in the maximum upper layer and contains Pt, and the second layer which is located in the following layer and contains Ir at least. And it is characterized by equipping the thickness of this first pass with the process which forms said second layer in which the process which is 40% or less and forms said lower electrode 20% or more to the thickness of the whole lower electrode contains Ir, and the process which forms said first pass containing Pt on this second layer at least.

[0013]

[Embodiment of the Invention] (Principle explanation) Drawing which measured the relation between the 100th page amount of preferred orientation of a piezo electric crystal thin film and the thickness of Ti nucleus is shown about the piezo electric crystal component which formed the lower electrode by which the laminating was carried out in the order of Ir layer / Pt layer / Ir layer, and Ti nucleus on ZrO₂ film, formed the piezo electric crystal precursor film in drawing 9 further, and it was made to crystallize. In <A HREF="/Tokujitu/tjitemdrw.ipdl?N0000=239&N0500=1E_N/;<=8;;8=///&N0001=49&N0552=9&N0553=000011" TARGET="tjitemdrw">> drawing 9, the thickness of the second layer of the lower electrode with which sign (a) contains Pt shows about 10% of case to the thickness of the whole lower electrode. In this case, the thickness of Ti nucleus is able to raise the 100th page amount of preferred orientation to about 90% in 4nm or more 6nm or less. However, when it is going to adjust the 100th page amount of preferred orientation to a different value from this, it is too large, and fluctuation of the 100th page amount of preferred orientation to change of the thickness of Ti nucleus is stabilized, and cannot obtain the desired 100th page amount of preferred orientation with sufficient repeatability.

[0014] On the other hand, sign (b) of drawing 9 shows the case where the ratio to the thickness of the whole lower electrode of the thickness of the second layer of the lower electrode containing Pt

is made to increase from the case of the above-mentioned (a). In this case, in response to the effect of Pt, the 111st page amount of preferred orientation of a piezo electric crystal thin film goes up, and while becoming lower than the case where the 100th page amount of preferred orientation is the above-mentioned (a), the value in which the thickness of Ti nucleus was stabilized by the 100th page amount of preferred orientation in 4nm or more 6nm or less is shown. [0015] Thus, while setting thickness of Ti nucleus to 4-6nm, it becomes possible by adjusting the rate of the thickness of Pt layer to the thickness of the whole lower electrode to double with repeatability sufficient in proportion of a request of the 100th page amount of preferred orientation (ratio of the 100th page amount of preferred orientation and the 111st page amount of preferred orientation).

[0016] Hereafter, the gestalt of suitable operation of this invention is explained, referring to a drawing.

[0017] (Operation gestalt 1) Drawing 1 is layer structure section drawing which expanded the piezo electric crystal component part of the ink jet type recording head in this operation gestalt.

[0018] As shown in drawing 1, on the oxide film 31, the piezo electric crystal component 40 carries out the laminating of ZrO₂ film 32, the lower electrode 42, the piezo electric crystal thin film 43, and the up electrode 44 one by one, and is constituted.

[0019] An oxide film 31 is formed for example, on the pressure room substrate 20 which consists of single crystal silicon with a thickness of 220 micrometers. Suitably, the film which consists of silicon oxide (SiO₂) is formed and obtained in thickness of 1.0 micrometers.

[0020] ZrO₂ film 32 is a layer equipped with elasticity, and constitutes the diaphragm 30 united with an oxide film 31. In order to equip this ZrO₂ film 32 with the function to give elasticity, it has 200nm or more thickness of 800nm or less preferably.

[0021] Between ZrO₂ film 32 and the lower electrode 42, a metal which sticks both layers, and the adhesion layer (not shown) which consists of titanium or chromium preferably may be prepared. An adhesion layer is formed in order that the adhesion to the installation side of a piezo electric crystal component may improve, and when the adhesion concerned can be secured, it is not necessary to form it. Moreover, since when preparing an adhesion layer enables it to secure minimum adhesion, preferably considers as the thickness of 10nm or more.

[0022] The third layer, to 423 and the thickness of the lower electrode 42, it is 30% or more 50% or less of thickness, and the lower electrode 42 consists of 424 and the first passes 425 which are located in the maximum upper layer and contain Ir containing Pt for which are located in the lowest layer and Ir is included the second layer. Especially a limit does not have the thickness of the whole lower electrode 42, for example, it sets it to 100nm. In addition, it is desirable that the relation of $dT=3.6 \times d0 + 2.4 \times d1 + 0.8 \times d2 + 2.3 \times d3$ is filled in the thickness of the adhesion layer before baking when the third layer of the thickness of the whole lower electrode after d3 and baking is set [the thickness of 423 / d1 and the thickness of the second layer] to dT for the thickness of d2 and the first pass, d0 and.

[0023] The layer (not shown) of Ti nucleus is formed on the lower electrode 42. Ti nucleus is 6nm or less in 4nm or more thickness.

[0024] The piezo electric crystal thin film 43 is the ferroelectric which consisted of crystals of usual piezoelectric ceramics, and consists of ferroelectricity piezoelectric ingredients, such as titanate-acid lead zirconate (PZT), and a thing which added metallic oxides, such as niobium oxide, nickel oxide, or a magnesium oxide, to this preferably. The presentation of the piezo electric crystal thin film 43 is suitably chosen in consideration of the property of a piezo electric crystal component, an application, etc. Specifically, lead titanate (PbTiO₃), titanate-acid lead zirconate (Pb (Zr, Ti) O₃), zirconic acid lead (PbZrO₃), a lead titanate lanthanum (Pb, La) (TiO₃), the PZT lanthanum (Pb, La) (Zr, Ti) (O₃), or magnesium niobic acid zirconium lead titanate (Pb(Zr, Ti) (Mg, Nb) O₃) is used suitably. Moreover, the film excellent in the piezo-electric property can be obtained by adding niobium (Nb) suitably in lead titanate or zirconic acid lead.

[0025] The 100th page amount of preferred orientation which measured the piezo electric crystal thin film 43 by the X diffraction wide angle method is 70% or less 40% or more. And the 111st page amount of preferred orientation of the 110th page amount of preferred orientation is the remainder 10% or less.

[0026] It is necessary to hold down the thickness of the piezo electric crystal thin film 43 to extent which a crack does not generate in a production process, and to make it thick to extent which presents sufficient displacement property on the other hand for example, and it is set to 1500nm.

[0027] The up electrode 44 is an electrode which becomes the lower electrode 42 and a pair, and is suitably constituted by Pt or Ir. The thickness of the up electrode 44 is about 50nm suitably.

[0028] Drawing 4 is the perspective view part sectional view showing the structure of the body of the ink jet type recording head of this invention.

[0029] As shown in drawing 4, an ink jet type record head consists of a nozzle plate 10, a pressure room substrate 20, a diaphragm 30, and a piezo electric crystal component 40.

[0030] The pressure room substrate 20 is equipped with the pressure room (cavity) 21, the side attachment wall 22, the reservoir 23, and the feed hopper 24. The pressure room 21 is formed as space stored in order to carry out the regurgitation of the ink etc. by etching substrates, such as silicon. The side attachment wall 22 is formed so that the pressure room 21 may be divided. The reservoir 23 serves as passage for filling ink in each pressure room 21 in common. The feed hopper 24 is formed in each pressure room 21 possible [installation of ink] from the reservoir 23.

[0031] A nozzle plate 10 is stuck on one field of the pressure room substrate 20 so that the nozzle 11 may be arranged in the location corresponding to each of the pressure room 21 established in the pressure room substrate 20.

[0032] The laminating of an oxide film 31 and the ZrO₂ film 32 is carried out, and a diaphragm 30 is formed, as mentioned above. The piezo electric crystal component 40 of this invention is formed as an electrostrictive actuator on the diaphragm 30 concerned. The piezo electric crystal component 40 equipped with the layer system shown in drawing 1, respectively is formed in the location on the diaphragm 30 corresponding to each pressure room 21. The ink tank opening 35 is formed in a diaphragm 30, and supply to the pressure room substrate 20 interior of it is attained at it in the ink stored in the ink tank which is not illustrated.

[0033] The pressure room substrate 20 with which the nozzle plate 10 and the diaphragm 30 were formed is stored in the case which is not illustrated further, and constitutes the ink jet type recording head.

[0034] In the above-mentioned configuration, if an electrical potential difference is impressed between the lower electrode 42 of the piezo electric crystal component 40, and the up electrode 44 and the piezo electric crystal component 40 is distorted, a diaphragm 30 will deform corresponding to the distortion. A pressure is applied to the ink in the pressure room 21 according to the deformation, and the drop of ink carries out the regurgitation from a nozzle 11.

[0035] The perspective view which explains the structure of the printer 100 of this operation gestalt to drawing 5 is shown. As shown in drawing 5, as for the printer 100, the ink jet type recording head 1, the tray 3, the exhaust port 4, the feed device 6, the control circuit 8, and control-panel 9 grade of this invention which is a printing means are prepared in the body 2 of a printer.

[0036] The tray 3 is constituted by the feed device 6 possible [supply] in the form 5 before printing. A control circuit 8 outputs the printing signal Sh which makes the feed signal Sd which makes a form 5 convey in the feed device 6, and printing perform to the ink jet type recording head 1 based on the printing information supplied from the control or the outside from a control panel 9. The feed device 6 consists of motor 600 grades which drive the rollers 601 and 602 and them which incorporate a form 5, and it is possible to incorporate a form 5 in a body 2 based on the feed signal Sd. If the ink jet type recording head 1 crosses the form 5 top supplied by the feed device 6, and is constituted movable and the printing signal Sh is supplied from a control circuit 8, when the piezo electric crystal component 40 deforms, it is possible to breathe out ink and to print on a form 5. The exhaust port 4 is the outlet which can discharge the form 5 which printing ended.

[0037] (Operation gestalt 2) Drawing 2 is layer structure section drawing which expanded the piezo electric crystal component part of the ink jet type recording head in the 2nd operation gestalt of this invention.

[0038] With this operation gestalt, the lower electrode 42 is 30% or more 50% or less of thickness to the thickness of the lower electrode 42, and the point which consists of 426 and the first

passes (the maximum upper layer) 427 containing Ir containing Pt the second layer (the lowest layer) differs from the above-mentioned operation gestalt 1.

[0039] (Operation gestalt 3) Drawing 3 is layer structure section drawing which expanded the piezo electric crystal component part of the ink jet type recording head in the 3rd operation gestalt of this invention.

[0040] With this operation gestalt, to 428 and the thickness of the lower electrode 42, it is 20% or more 40% or less of thickness, and the second layer (the lowest layer) of the point which consists of the first passes (the maximum upper layer) 429 containing Pt for which the lower electrode 42 contains Ir differs from the above-mentioned operation gestalt 1.

[0041] (The manufacture approach) Next, the manufacture approach of the piezo electric crystal component of this invention is explained. Drawing 6 and drawing 7 are the cross sections showing the manufacture approach of the piezo electric crystal component of this invention, and an ink jet type recording head.

[0042] an oxide-film formation process (S1) — this process is a process which forms the oxide film 31 which carries out high temperature processing in the oxidizing atmosphere containing oxygen or a steam, and consists of oxidation silicon (SiO_2). A CVD method besides the usually used oxidizing [thermally] method can also be used for this process.

[0043] It is the process which forms ZrO_2 film 32 on the oxide film 31 on the process (S2) pressure room substrate 20 which forms ZrO_2 film. This ZrO_2 film 32 carries out high temperature processing of what formed the layer of Zr with the spatter or the vacuum deposition method in an oxygen ambient atmosphere, and is obtained.

[0044] If it is in the lower electrode concerning the process (S3) operation gestalt 1 which forms a lower electrode It consists of the process which contains Ir on ZrO_2 film 32 and which forms 423 [layer / third], a process which is 30% or more 50% or less of thickness to the thickness of the lower electrode 42 on this third layer, and contains Pt and which forms 424 [layer / second], and a process which forms the first pass 425 containing Ir on this second layer.

[0045] If it is in the lower electrode concerning the operation gestalt 2, on ZrO_2 film 32, to the thickness of the lower electrode 42, it is 30% or more 50% or less of thickness, and consists of a process containing Pt which forms 426 [layer / second], and a process which forms the first pass 424 containing Ir on this second layer.

[0046] If it is in the lower electrode concerning the operation gestalt 3, it consists of a process which contains Ir on ZrO_2 film 32 and which forms 428 [layer / second], and a process which forms the first pass 429 which is 20% or more 40% or less of thickness, and contains Pt to the thickness of the lower electrode 42 on this second layer.

[0047] On ZrO_2 film 32, each class 423-429 makes Ir or Pt adhere in a spatter etc., and forms it, respectively. In addition, in advance of formation of the lower electrode 42, the adhesion layer (not shown) which consists of titanium or chromium may be formed with a spatter or a vacuum deposition method.

[0048] This process is a process which forms a titanium crystal (not shown) in the shape of an island on the lower electrode 42 by a spatter etc. like ** which forms Ti nucleus (layer). By growing up PZT by using a titanium crystal as a nucleus, crystal growth happens from a lower electrode side, and forming Ti nucleus (layer) has it, and it is because a column-like crystal is obtained.

[precise]

[0049] the process (S4) which forms the piezo electric crystal precursor film — this process is a process which forms piezo electric crystal precursor film 43' with a sol-gel method.

[0050] First, the sol which consists of an organic metal alkoxide solution is applied on Ti nucleus by the applying methods, such as a spin coat. Subsequently, fixed time amount desiccation is carried out with constant temperature, and a solvent is evaporated. After desiccation, fixed time amount cleaning is further carried out at a predetermined elevated temperature under an atmospheric-air ambient atmosphere, and the pyrolysis of the organic ligand configured to the metal is carried out, and it considers as a metallic oxide. Each process of this spreading, desiccation, and cleaning is repeated 4 times or more the number of predetermined times, for example, and the laminating of the piezo electric crystal precursor film of four or more layers is carried out. By these desiccation and cleaning processings, the metal alkoxide and acetate in a solution form the network of a metal,

oxygen, and a metal through the pyrolysis of a ligand.

[0051] It is the process which it calcinates [process] and crystallizes the piezo electric crystal precursor film after formation of baking process (S5) piezo electric crystal precursor film 43'. By this baking, piezo electric crystal precursor film 43' changes to the thin film in which the perovskite crystal structure is formed in from the precursor of an amorphous condition, and an electric machine conversion operation is shown, and the 100th page amount of preferred orientation measured by the X diffraction wide angle method serves as 70% or less of piezo electric crystal thin film 40% or more.

[0052] The up electrode 44 is formed by electron beam vacuum deposition or the spatter on the piezo electric crystal thin film 43 at the up electrode formation process (S6) last.

[0053] If it etches and operates orthopedically in the configuration of having been suitable for the activity part and the piezoelectric component 40 obtained at the above process is manufactured possible [impression of an electrical potential difference] to vertical inter-electrode one, it is possible to make it operate as a piezo electric crystal component of this invention.

[0054] The obtained piezoelectric component 40 is etched so that an ink jet type recording head may be suited, and it is explained below about the process fabricated in the configuration as a piezo electric crystal component based on drawing 7 .

[0055] a piezo electric crystal component forming cycle (S7) — the mask of the piezo electric crystal component 40 is first carried out to the configuration fitted to each pressure room 21, and the perimeter is etched. Specifically, the resist ingredient of uniform thickness is first applied on an up electrode using approaches, such as the spinner method and a spray method. Subsequently, after forming a mask in the configuration of a piezo electric crystal component, exposure and development of are done, and a resist pattern is formed on the up electrode 44. Ion milling or the dry etching method usually used for this is applied, etching clearance of the up electrode 44, the piezo electric crystal thin film 43, and the lower electrode 42 is carried out, and each piezo electric crystal component 40 is fabricated.

[0056] Anisotropic etching which used activity gases, such as anisotropic etching or parallel plate mold reactive ion etching, is performed to the field of another side of a pressure room formation process (S8), next the pressure room substrate 20 with which the piezo electric crystal component 40 was formed, and the pressure room 21 is formed in it. The part left behind without being etched becomes a side attachment wall 22.

[0057] A nozzle plate 10 is stuck on the pressure room substrate 20 after etching with adhesives at the nozzle plate lamination process (S9) last. the time of lamination — each nozzle 11 — the pressure room 21 — alignment is carried out so that it may be arranged in each space. The case which does not illustrate the pressure room substrate 20 with which the nozzle plate 10 was stuck is made to complete installation and the ink jet type recording head 1.

[0058] (Example) While changing various ratios of the thickness of Pt layer [as opposed to the thickness of the whole lower electrode for the piezo electric crystal component by the manufacture approach of the above-mentioned operation gestalt 1] and manufacturing some, some piezo electric crystal components were manufactured as an example of a comparison also with ratios other than the ratio shown with the above-mentioned operation gestalt.

[0059] Drawing which measured the relation between the 100th page amount of preferred orientation and a piezoelectric constant d31 is shown about the piezo electric crystal component obtained as a result by drawing 8 . The piezoelectric constant d31 is especially measured in both high frequency (it measures using 14kHz and an ink jet head), and low frequency (it measures using DC actuation and a cantilever). In drawing 8 , when the 100th page amount of preferred orientation is small, it is shown that the 111st page amount of preferred orientation is large.

[0060] As shown in drawing 8 , although the piezo-electric multiplier d31 is so high that the 111st page amount of preferred orientation is high, when the 100th page amount of preferred orientation is 70% or less 40% or more, by low frequency actuation, it turns out that a suitable piezo-electric property is acquired by RF actuation which is used for an ink jet head. Moreover, that the piezo electric crystal component which shows such the amount of preferred orientation was manufactured was the case where the thickness of Pt layer to the thickness of the whole lower electrode was 30 – 50%.

[0061] In addition, it asked for measurement of a piezoelectric constant d_{31} from the variation rate at the time of electrical-potential-difference impression. Moreover, the "100th page amount of preferred orientation" said to this application means the ratio to the sum of $I(100)$ of $I(100)$, and $I(110)$ and $I(111)$, when diffraction reinforcement of the peak (2θ) corresponding to the XYZ side when using CuK alpha rays in an X diffraction wide angle method is set to $I(XYZ)$.

[0062] (Other modifications) it not being based on the above-mentioned operation gestalt, but being able to deform and be adapted for versatility of this invention For example, the piezo electric crystal component manufactured by this invention can be adapted for manufacture of ferroelectric equipments, such as not only the piezo electric crystal component of the above-mentioned ink jet type recording head but a non-volatile semiconductor memory, a thin film capacitor, a pyroelectricity detector, a sensor, a surface-acoustic-waves optical waveguide, optical memory, a space optical modulator, a frequency doubler for diode lasers, etc., a dielectric device, pyroelectricity equipment, a piezoelectric device, and an electro-optic device.

[0063]

[Effect of the Invention] According to this invention, it is stabilized and the 100th page amount of preferred orientation of a piezo electric crystal thin film can be obtained with sufficient repeatability. As a result, the ratio of the 100th page amount of preferred orientation of a piezo electric crystal thin film and the 111st page amount of preferred orientation can be obtained with sufficient repeatability. The ink JIETO type recording head and printer list using the piezo electric crystal component and this which were equipped with the piezo-electric high property stabilized also in any of a RF and low frequency by this can be provided with the manufacture approach of a piezo electric crystal component.

[Translation done.]

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TECHNICAL FIELD

[Field of the Invention] When this invention relates to the piezo electric crystal component which has an electric machine conversion function and is especially used for an ink jet type recording head, it relates to the manufacture approach of the piezo electric crystal component from which the outstanding piezo-electric property is acquired, an ink jet type recording head, a printer, and a piezo electric crystal component.

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PRIOR ART

[Description of the Prior Art] A piezo electric crystal component is used for an ink jet type recording head as a driving source of the ink regurgitation of a printer. Generally this piezo electric crystal component is equipped with a piezo electric crystal thin film, the up electrode arranged on both sides of this, and a lower electrode, and is constituted.

[0003] The piezo electric crystal component which aimed at the property improvement is developed by specifying conventionally the crystal structure of the thin film which consists of PZT (PZT), or making Ti nucleus form on a lower electrode. For example, the PZT thin film which equipped JP,10-81016,A with the crystal structure of a rhombohedral system, and equipped it with the predetermined amount of preferred orientation is indicated. Moreover, the piezo electric crystal component in which the titanium nucleus was formed on the lower electrode of Ir is indicated by JP,8-335676,A.

[0004] However, with the conventional piezo electric crystal component, there was a problem that it was difficult to be stabilized and to obtain the predetermined amount of preferred orientation of a piezo electric crystal thin film with sufficient repeatability. It is difficult for such a piezo electric crystal component to acquire the stable piezo-electric high property, and it has become the factor which cannot fully obtain an ink jet type recording head or the printing engine performance of a printer.

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EFFECT OF THE INVENTION

[Effect of the Invention] According to this invention, it is stabilized and the 100th page amount of preferred orientation of a piezo electric crystal thin film can be obtained with sufficient repeatability. As a result, the ratio of the 100th page amount of preferred orientation of a piezo electric crystal thin film and the 111st page amount of preferred orientation can be obtained with sufficient repeatability. The ink JIETO type recording head and printer list using the piezo electric crystal component and this which were equipped with the piezo-electric high property stabilized also in any of a RF and low frequency by this can be provided with the manufacture approach of a piezo electric crystal component.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] The object of this invention is by canceling the above-mentioned trouble, being stabilized and obtaining the predetermined amount of preferred orientation of a piezo electric crystal thin film with sufficient repeatability to provide the ink JIETO type recording head using a piezo electric crystal component and this equipped with the stable piezo-electric high property, and a printer list with the manufacture approach of a piezo electric crystal component.

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MEANS

[Means for Solving the Problem] The piezo electric crystal component of this invention is a piezo electric crystal component equipped with the lower electrode formed on ZrO₂ film, the piezo electric crystal film formed on this lower electrode, and the up electrode formed on this piezo electric crystal film, and the 100th page amount of preferred orientation which measured said piezo electric crystal film by the X diffraction wide angle method is characterized by being 70% or less 40% or more.

[0007] Moreover, it is desirable that the 110th page amount of preferred orientation is 10% or less, and the 111st page amount of preferred orientation is the remainder.

[0008] the first pass which said especially lower electrode is located in ** maximum upper layer, and contains Ir, and the second layer which is located in the following layer and contains Pt — at least — having — and — this — to the thickness of the whole lower electrode, the thickness of the second layer is 50% or less, forms with a 4nm or more thickness [6nm or less] Ti layer on said lower electrode 30% or more, and forms the piezo electric crystal film on this Ti layer. **—1 [moreover,] — the third layer which is said layer [second] following layer, is located in the lowest layer of said lower electrode, and contains Ir — having — **** — **—2 — said second layer which contains Pt among said lower electrodes may be the lowest layer.

[0009] Moreover, said lower electrode is equipped with the first pass which is located in ** maximum upper layer and contains Pt, and the second layer which is located in the following layer and contains Ir at least. And it is characterized by for the thickness of this first pass being 40% or less, having formed the layer of with a 4nm or more thickness [6nm or less] Ti nucleus on said lower electrode 20% or more, to the thickness of the whole lower electrode, and forming the piezo electric crystal film on this Ti layer. **—1 [moreover,] — said second layer which contains Ir among said lower electrodes may be the lowest layer.

[0010] Moreover, this invention is an ink jet type recording head characterized by being prepared as an electrostrictive actuator on the diaphragm whose above-mentioned piezo electric crystal component is an installation side.

[0011] Moreover, this invention is a printer characterized by having this ink jet type recording head as a printing means.

[0012] Furthermore, the process at which this invention forms ZrO₂ film on a substrate and the process which forms a lower electrode on this ZrO₂ film, The process which forms the layer of with a 4nm or more thickness [6nm or less] Ti nucleus on this lower electrode, It is the manufacture approach of a piezo electric crystal component equipped with the process which forms the piezo electric crystal precursor film on this Ti layer, and a baking process. The ** aforementioned lower electrode It has at least the first pass which is located in the maximum upper layer and contains Ir, and the second layer which is located in the following layer and contains Pt. and — this — the process in which the thickness of the second layer is 50% or less, and forms said lower electrode 30% or more to the thickness of the whole lower electrode [whether it has at least the process which forms said second layer containing Pt, and the process which forms said first pass containing Ir on this second layer, and] Or the ** aforementioned lower electrode is equipped with the first pass which is located in the maximum upper layer and contains Pt, and the second layer which is located in the following layer and contains Ir at least.

And it is characterized by equipping the thickness of this first pass with the process which forms said second layer in which the process which is 40% or less and forms said lower electrode 20% or more to the thickness of the whole lower electrode contains Ir, and the process which forms said first pass containing Pt on this second layer at least.

[0013]

[Embodiment of the Invention] (Principle explanation) Drawing which measured the relation between the 100th page amount of preferred orientation of a piezo electric crystal thin film and the thickness of Ti nucleus is shown about the piezo electric crystal component which formed the lower electrode by which the laminating was carried out in the order of Ir layer / Pt layer / Ir layer, and Ti nucleus on ZrO₂ film, formed the piezo electric crystal precursor film in drawing 9 further, and it was made to crystallize. In drawing 9, the thickness of the second layer of the lower electrode with which sign (a) contains Pt shows about 10% of case to the thickness of the whole lower electrode. In this case, the thickness of Ti nucleus is able to raise the 100th page amount of preferred orientation to about 90% in 4nm or more 6nm or less. However, when it is going to adjust the 100th page amount of preferred orientation to a different value from this, it is too large, and fluctuation of the 100th page amount of preferred orientation to change of the thickness of Ti nucleus is stabilized, and cannot obtain the desired 100th page amount of preferred orientation with sufficient repeatability.

[0014] On the other hand, sign (b) of drawing 9 shows the case where the ratio to the thickness of the whole lower electrode of the thickness of the second layer of the lower electrode containing Pt is made to increase from the case of the above-mentioned (a). In this case, in response to the effect of Pt, the 111st page amount of preferred orientation of a piezo electric crystal thin film goes up, and while becoming lower than the case where the 100th page amount of preferred orientation is the above-mentioned (a), the value in which the thickness of Ti nucleus was stabilized by the 100th page amount of preferred orientation in 4nm or more 6nm or less is shown.

[0015] Thus, while setting thickness of Ti nucleus to 4-6nm, it becomes possible by adjusting the rate of the thickness of Pt layer to the thickness of the whole lower electrode to double with repeatability sufficient in proportion of a request of the 100th page amount of preferred orientation (ratio of the 100th page amount of preferred orientation and the 111st page amount of preferred orientation).

[0016] Hereafter, the gestalt of suitable operation of this invention is explained, referring to a drawing.

[0017] (Operation gestalt 1) Drawing 1 is layer structure section drawing which expanded the piezo electric crystal component part of the ink jet type recording head in this operation gestalt.

[0018] As shown in drawing 1, on the oxide film 31, the piezo electric crystal component 40 carries out the laminating of ZrO₂ film 32, the lower electrode 42, the piezo electric crystal thin film 43, and the up electrode 44 one by one, and is constituted.

[0019] An oxide film 31 is formed for example, on the pressure room substrate 20 which consists of single crystal silicon with a thickness of 220 micrometers. Suitably, the film which consists of silicon oxide (SiO₂) is formed and obtained in thickness of 1.0 micrometers.

[0020] ZrO₂ film 32 is a layer equipped with elasticity, and constitutes the diaphragm 30 united with an oxide film 31. In order to equip this ZrO₂ film 32 with the function to give elasticity, it has 200nm or more thickness of 800nm or less preferably.

[0021] Between ZrO₂ film 32 and the lower electrode 42, a metal which sticks both layers, and the adhesion layer (not shown) which consists of titanium or chromium preferably may be prepared. An adhesion layer is formed in order that the adhesion to the installation side of a piezo electric crystal component may improve, and when the adhesion concerned can be secured, it is not necessary to form it. Moreover, since when preparing an adhesion layer enables it to secure minimum adhesion, preferably considers as the thickness of 10nm or more.

[0022] The third layer, to 423 and the thickness of the lower electrode 42, it is 30% or more 50% or less of thickness, and the lower electrode 42 consists of 424 and the first passes 425 which are located in the maximum upper layer and contain Ir containing Pt for which are located in the lowest layer and Ir is included the second layer. Especially a limit does not have the thickness of the whole lower electrode 42, for example, it sets it to 100nm. In addition, it is desirable that the

relation of $dT=3.6 \times d_0 + 2.4 \times d_1 + 0.8 \times d_2 + 2.3 \times d_3$ is filled in the thickness of the adhesion layer before baking when the third layer of the thickness of the whole lower electrode after d_3 and baking is set [the thickness of $423 / d_1$ and the thickness of the second layer] to dT for the thickness of d_2 and the first pass, d_0 and.

[0023] The layer (not shown) of Ti nucleus is formed on the lower electrode 42. Ti nucleus is 6nm or less in 4nm or more thickness.

[0024] The piezo electric crystal thin film 43 is the ferroelectric which consisted of crystals of usual piezoelectric ceramics, and consists of ferroelectricity piezoelectric ingredients, such as titanate-acid lead zirconate (PZT), and a thing which added metallic oxides, such as niobium oxide, nickel oxide, or a magnesium oxide, to this preferably. The presentation of the piezo electric crystal thin film 43 is suitably chosen in consideration of the property of a piezo electric crystal component, an application, etc. Specifically, lead titanate ($PbTiO_3$), titanate-acid lead zirconate ($Pb(Zr, Ti)O_3$), zirconic acid lead ($PbZrO_3$), a lead titanate lanthanum ($Pb, La(TiO_3)$), the PZT lanthanum ($Pb, La(Zr, Ti)O_3$), or magnesium niobic acid zirconium lead titanate ($Pb(Zr, Ti)(Mg, Nb)O_3$) is used suitably. Moreover, the film excellent in the piezo-electric property can be obtained by adding niobium (Nb) suitably in lead titanate or zirconic acid lead.

[0025] The 100th page amount of preferred orientation which measured the piezo electric crystal thin film 43 by the X diffraction wide angle method is 70% or less 40% or more. And the 111st page amount of preferred orientation of the 110th page amount of preferred orientation is the remainder 10% or less.

[0026] It is necessary to hold down the thickness of the piezo electric crystal thin film 43 to extent which a crack does not generate in a production process, and to make it thick to extent which presents sufficient displacement property on the other hand for example, and it is set to 1500nm.

[0027] The up electrode 44 is an electrode which becomes the lower electrode 42 and a pair, and is suitably constituted by Pt or Ir. The thickness of the up electrode 44 is about 50nm suitably.

[0028] Drawing 4 is the perspective view part sectional view showing the structure of the body of the ink jet type recording head of this invention.

[0029] As shown in drawing 4, an ink jet type record head consists of a nozzle plate 10, a pressure room substrate 20, a diaphragm 30, and a piezo electric crystal component 40.

[0030] The pressure room substrate 20 is equipped with the pressure room (cavity) 21, the side attachment wall 22, the reservoir 23, and the feed hopper 24. The pressure room 21 is formed as space stored in order to carry out the regurgitation of the ink etc. by etching substrates, such as silicon. The side attachment wall 22 is formed so that the pressure room 21 may be divided. The reservoir 23 serves as passage for filling ink in each pressure room 21 in common. The feed hopper 24 is formed in each pressure room 21 possible [installation of ink] from the reservoir 23.

[0031] A nozzle plate 10 is stuck on one field of the pressure room substrate 20 so that the nozzle 11 may be arranged in the location corresponding to each of the pressure room 21 established in the pressure room substrate 20.

[0032] The laminating of an oxide film 31 and the ZrO_2 film 32 is carried out, and a diaphragm 30 is formed, as mentioned above. The piezo electric crystal component 40 of this invention is formed as an electrostrictive actuator on the diaphragm 30 concerned. The piezo electric crystal component 40 equipped with the layer system shown in drawing 1, respectively is formed in the location on the diaphragm 30 corresponding to each pressure room 21. The ink tank opening 35 is formed in a diaphragm 30, and supply to the pressure room substrate 20 interior of it is attained at it in the ink stored in the ink tank which is not illustrated.

[0033] The pressure room substrate 20 with which the nozzle plate 10 and the diaphragm 30 were formed is stored in the case which is not illustrated further, and constitutes the ink jet type recording head.

[0034] In the above-mentioned configuration, if an electrical potential difference is impressed between the lower electrode 42 of the piezo electric crystal component 40, and the up electrode 44 and the piezo electric crystal component 40 is distorted, a diaphragm 30 will deform corresponding to the distortion. A pressure is applied to the ink in the pressure room 21 according to the deformation, and the drop of ink carries out the regurgitation from a nozzle 11.

[0035] The perspective view which explains the structure of the printer 100 of this operation gestalt to drawing 5 is shown. As shown in drawing 5, as for the printer 100, the ink jet type recording head 1, the tray 3, the exhaust port 4, the feed device 6, the control circuit 8, and control-panel 9 grade of this invention which is a printing means are prepared in the body 2 of a printer.

[0036] The tray 3 is constituted by the feed device 6 possible [supply] in the form 5 before printing. A control circuit 8 outputs the printing signal Sh which makes the feed signal Sd which makes a form 5 convey in the feed device 6, and printing perform to the ink jet type recording head 1 based on the printing information supplied from the control or the outside from a control panel 9. The feed device 6 consists of motor 600 grades which drive the rollers 601 and 602 and them which incorporate a form 5, and it is possible to incorporate a form 5 in a body 2 based on the feed signal Sd. If the ink jet type recording head 1 crosses the form 5 top supplied by the feed device 6, and is constituted movable and the printing signal Sh is supplied from a control circuit 8, when the piezo electric crystal component 40 deforms, it is possible to breathe out ink and to print on a form 5. The exhaust port 4 is the outlet which can discharge the form 5 which printing ended.

[0037] (Operation gestalt 2) Drawing 2 is layer structure section drawing which expanded the piezo electric crystal component part of the ink jet type recording head in the 2nd operation gestalt of this invention.

[0038] With this operation gestalt, the lower electrode 42 is 30% or more 50% or less of thickness to the thickness of the lower electrode 42, and the point which consists of 426 and the first passes (the maximum upper layer) 427 containing Ir containing Pt the second layer (the lowest layer) differs from the above-mentioned operation gestalt 1.

[0039] (Operation gestalt 3) Drawing 3 is layer structure section drawing which expanded the piezo electric crystal component part of the ink jet type recording head in the 3rd operation gestalt of this invention.

[0040] With this operation gestalt, to 428 and the thickness of the lower electrode 42, it is 20% or more 40% or less of thickness, and the second layer (the lowest layer) of the point which consists of the first passes (the maximum upper layer) 429 containing Pt for which the lower electrode 42 contains Ir differs from the above-mentioned operation gestalt 1.

[0041] (The manufacture approach) Next, the manufacture approach of the piezo electric crystal component of this invention is explained. Drawing 6 and drawing 7 are the cross sections showing the manufacture approach of the piezo electric crystal component of this invention, and an ink jet type recording head.

[0042] an oxide-film formation process (S1) — this process is a process which forms the oxide film 31 which carries out high temperature processing in the oxidizing atmosphere containing oxygen or a steam, and consists of oxidation silicon (SiO₂). A CVD method besides the usually used oxidizing [thermally] method can also be used for this process.

[0043] It is the process which forms ZrO₂ film 32 on the oxide film 31 on the process (S2) pressure room substrate 20 which forms ZrO₂ film. This ZrO₂ film 32 carries out high temperature processing of what formed the layer of Zr with the spatter or the vacuum deposition method in an oxygen ambient atmosphere, and is obtained.

[0044] If it is in the lower electrode concerning the process (S3) operation gestalt 1 which forms a lower electrode It consists of the process which contains Ir on ZrO₂ film 32 and which forms 423 [layer / third], a process which is 30% or more 50% or less of thickness to the thickness of the lower electrode 42 on this third layer, and contains Pt and which forms 424 [layer / second], and a process which forms the first pass 425 containing Ir on this second layer.

[0045] If it is in the lower electrode concerning the operation gestalt 2, on ZrO₂ film 32, to the thickness of the lower electrode 42, it is 30% or more 50% or less of thickness, and consists of a process containing Pt which forms 426 [layer / second], and a process which forms the first pass 424 containing Ir on this second layer.

[0046] If it is in the lower electrode concerning the operation gestalt 3, it consists of a process which contains Ir on ZrO₂ film 32 and which forms 428 [layer / second], and a process which forms the first pass 429 which is 20% or more 40% or less of thickness, and contains Pt to the thickness of the lower electrode 42 on this second layer.

[0047] On ZrO₂ film 32, each class 423–429 makes Ir or Pt adhere in a spatter etc., and forms it, respectively. In addition, in advance of formation of the lower electrode 42, the adhesion layer (not shown) which consists of titanium or chromium may be formed with a spatter or a vacuum deposition method.

[0048] This process is a process which forms a titanium crystal (not shown) in the shape of an island on the lower electrode 42 by a spatter etc. like ** which forms Ti nucleus (layer). By growing up PZT by using a titanium crystal as a nucleus, crystal growth happens from a lower electrode side, and forming Ti nucleus (layer) has it, and it is because a column-like crystal is obtained.

[precise]

[0049] the process (S4) which forms the piezo electric crystal precursor film — this process is a process which forms piezo electric crystal precursor film 43' with a sol-gel method.

[0050] First, the sol which consists of an organic metal alkoxide solution is applied on Ti nucleus by the applying methods, such as a spin coat. Subsequently, fixed time amount desiccation is carried out with constant temperature, and a solvent is evaporated. After desiccation, fixed time amount cleaning is further carried out at a predetermined elevated temperature under an atmospheric-air ambient atmosphere, and the pyrolysis of the organic ligand configured to the metal is carried out, and it considers as a metallic oxide. Each process of this spreading, desiccation, and cleaning is repeated 4 times or more the number of predetermined times, for example, and the laminating of the piezo electric crystal precursor film of four or more layers is carried out. By these desiccation and cleaning processings, the metal alkoxide and acetate in a solution form the network of a metal, oxygen, and a metal through the pyrolysis of a ligand.

[0051] It is the process which it calcinates [process] and crystallizes the piezo electric crystal precursor film after formation of baking process (S5) piezo electric crystal precursor film 43'. By this baking, piezo electric crystal precursor film 43' changes to the thin film in which the perovskite crystal structure is formed in from the precursor of an amorphous condition, and an electric machine conversion operation is shown, and the 100th page amount of preferred orientation measured by the X diffraction wide angle method serves as 70% or less of piezo electric crystal thin film 40% or more.

[0052] The up electrode 44 is formed by electron beam vacuum deposition or the spatter on the piezo electric crystal thin film 43 at the up electrode formation process (S6) last.

[0053] If it etches and operates orthopedically in the configuration of having been suitable for the activity part and the piezoelectric component 40 obtained at the above process is manufactured possible [impression of an electrical potential difference] to vertical inter-electrode one, it is possible to make it operate as a piezo electric crystal component of this invention.

[0054] The obtained piezoelectric component 40 is etched so that an ink jet type recording head may be suited, and it is explained below about the process fabricated in the configuration as a piezo electric crystal component based on drawing 7 .

[0055] a piezo electric crystal component forming cycle (S7) — the mask of the piezo electric crystal component 40 is first carried out to the configuration fitted to each pressure room 21, and the perimeter is etched. Specifically, the resist ingredient of uniform thickness is first applied on an up electrode using approaches, such as the spinner method and a spray method. Subsequently, after forming a mask in the configuration of a piezo electric crystal component, exposure and development of are done, and a resist pattern is formed on the up electrode 44. Ion milling or the dry etching method usually used for this is applied, etching clearance of the up electrode 44, the piezo electric crystal thin film 43, and the lower electrode 42 is carried out, and each piezo electric crystal component 40 is fabricated.

[0056] Anisotropic etching which used activity gases, such as anisotropic etching or parallel plate mold reactive ion etching, is performed to the field of another side of a pressure room formation process (S8), next the pressure room substrate 20 with which the piezo electric crystal component 40 was formed, and the pressure room 21 is formed in it. The part left behind without being etched becomes a side attachment wall 22.

[0057] A nozzle plate 10 is stuck on the pressure room substrate 20 after etching with adhesives at the nozzle plate lamination process (S9) last. the time of lamination — each nozzle 11 — the pressure room 21 — alignment is carried out so that it may be arranged in each space. The case

which does not illustrate the pressure room substrate 20 with which the nozzle plate 10 was stuck is made to complete installation and the ink jet type recording head 1.

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EXAMPLE

(Example) While changing various ratios of the thickness of Pt layer [as opposed to the thickness of the whole lower electrode for the piezo electric crystal component by the manufacture approach of the above-mentioned operation gestalt 1] and manufacturing some, some piezo electric crystal components were manufactured as an example of a comparison also with ratios other than the ratio shown with the above-mentioned operation gestalt.

[0059] Drawing which measured the relation between the 100th page amount of preferred orientation and a piezoelectric constant d31 is shown about the piezo electric crystal component obtained as a result by drawing 8 . The piezoelectric constant d31 is especially measured in both high frequency (it measures using 14kHz and an ink jet head), and low frequency (it measures using DC actuation and a cantilever). In drawing 8 , when the 100th page amount of preferred orientation is small, it is shown that the 111st page amount of preferred orientation is large.

[0060] As shown in drawing 8 , although the piezo-electric multiplier d31 is so high that the 111st page amount of preferred orientation is high, when the 100th page amount of preferred orientation is 70% or less 40% or more, by low frequency actuation, it turns out that a suitable piezo-electric property is acquired by RF actuation which is used for an ink jet head. Moreover, that the piezo electric crystal component which shows such the amount of preferred orientation was manufactured was the case where the thickness of Pt layer to the thickness of the whole lower electrode was 30 - 50%.

[0061] In addition, it asked for measurement of a piezoelectric constant d31 from the variation rate at the time of electrical-potential-difference impression. Moreover, the "100th page amount of preferred orientation" said to this application means the ratio to the sum of I (100) of I (100), and I (110) and I (111), when diffraction reinforcement of the peak (2theta) corresponding to the XYZ side when using CuK alpha rays in an X diffraction wide angle method is set to I (XYZ).

[0062] (Other modifications) it not being based on the above-mentioned operation gestalt, but being able to deform and be adapted for versatility of this invention For example, the piezo electric crystal component manufactured by this invention can be adapted for manufacture of ferroelectric equipments, such as not only the piezo electric crystal component of the above-mentioned ink jet type recording head but a non-volatile semiconductor memory, a thin film capacitor, a pyroelectricity detector, a sensor, a surface-acoustic-waves optical waveguide, optical memory, a space optical modulator, a frequency doubler for diode lasers, etc., a dielectric device, pyroelectricity equipment, a piezoelectric device, and an electro-optic device.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The sectional view of the piezo electric crystal component of the operation gestalt 1

[Drawing 2] The sectional view of the piezo electric crystal component of the operation gestalt 2

[Drawing 3] The sectional view of the piezo electric crystal component of the operation gestalt 3

[Drawing 4] The perspective view part sectional view showing the structure of the body of an ink jet type recording head

[Drawing 5] The perspective view showing the structure of the printer which used the ink jet type recording head of this invention

[Drawing 6] The cross section showing the manufacture approach of the ink jet type recording head of this invention

[Drawing 7] The cross section showing the manufacture approach of the ink jet type recording head of this invention

[Drawing 8] Drawing showing the relation between the 100th page amount of preferred orientation and a piezoelectric constant d_{31}

[Drawing 9] Drawing showing the relation between the 100th page amount of preferred orientation and the thickness of Ti nucleus

[Description of Notations]

20 Pressure Room Substrate

30 Diaphragm

31 Oxide Film

32 ZrO₂ Film

40 Piezo Electric Crystal Component

42 Lower Electrode

423 Third Layer (Ir)

424 Second Layer (Pt)

425 First Pass (Ir)

426 Second Layer (Pt)

427 First Pass (Ir)

428 Second Layer (Ir)

429 First Pass (Pt)

43 Piezo Electric Crystal Thin Film

44 Up Electrode

[Translation done.]

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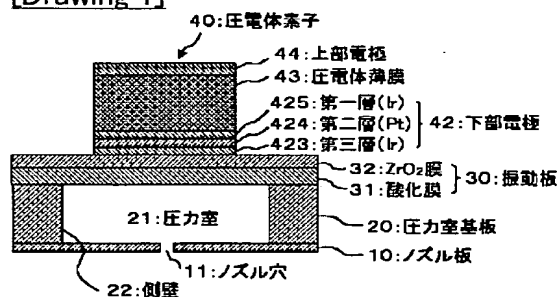
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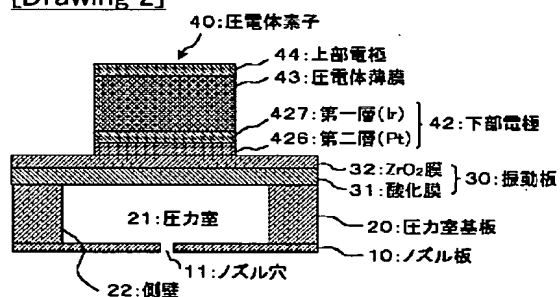
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DRAWINGS

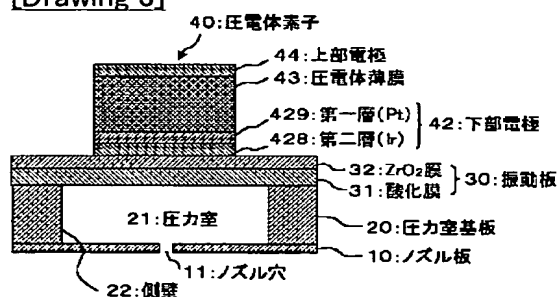
[Drawing 1]



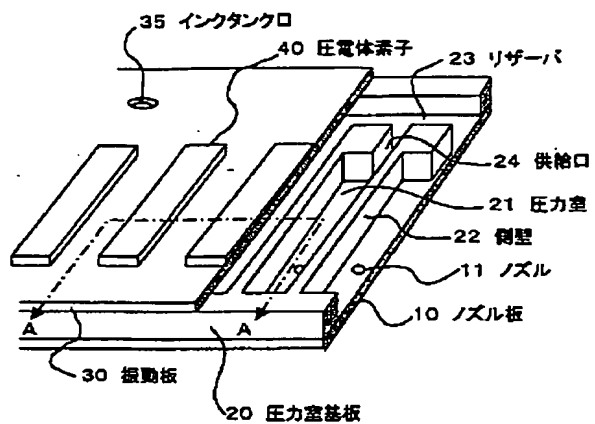
[Drawing 2]



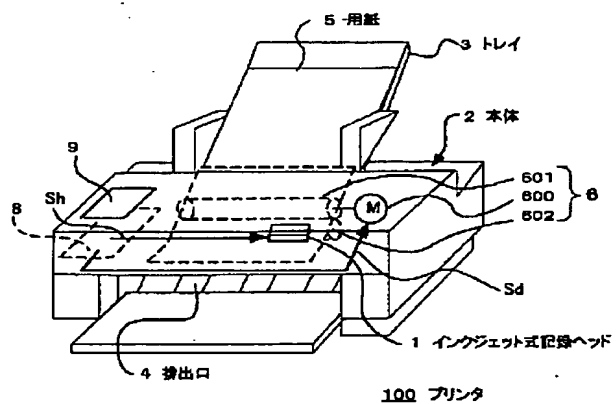
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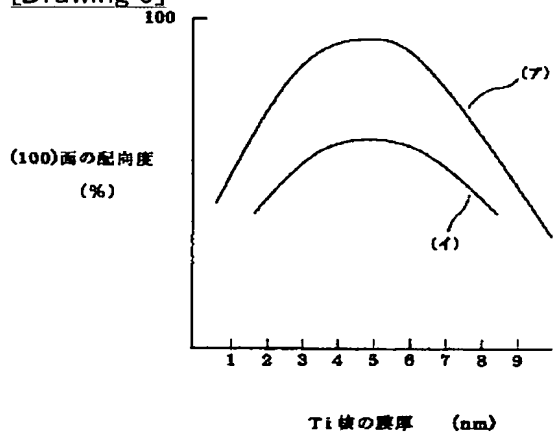
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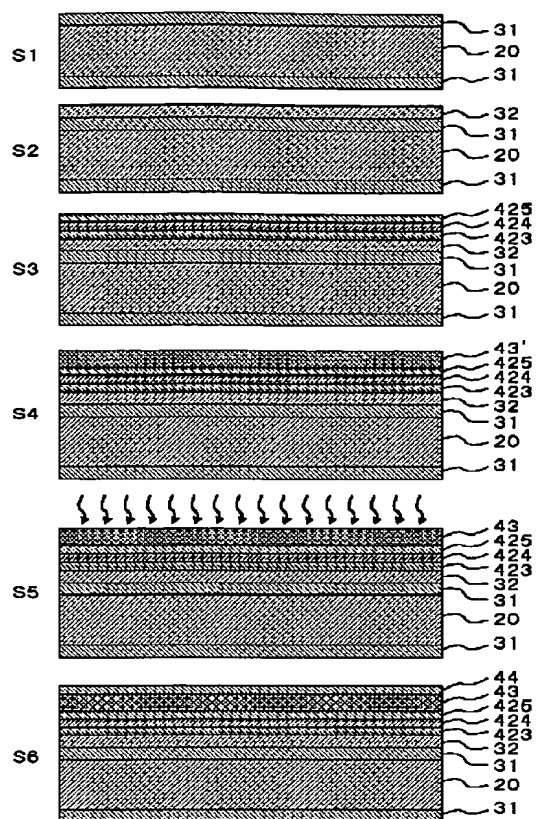
[Drawing 5]



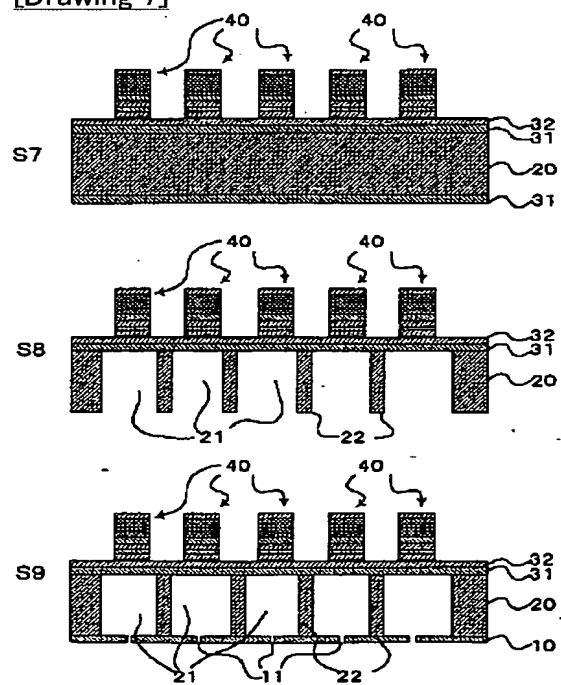
[Drawing 9]



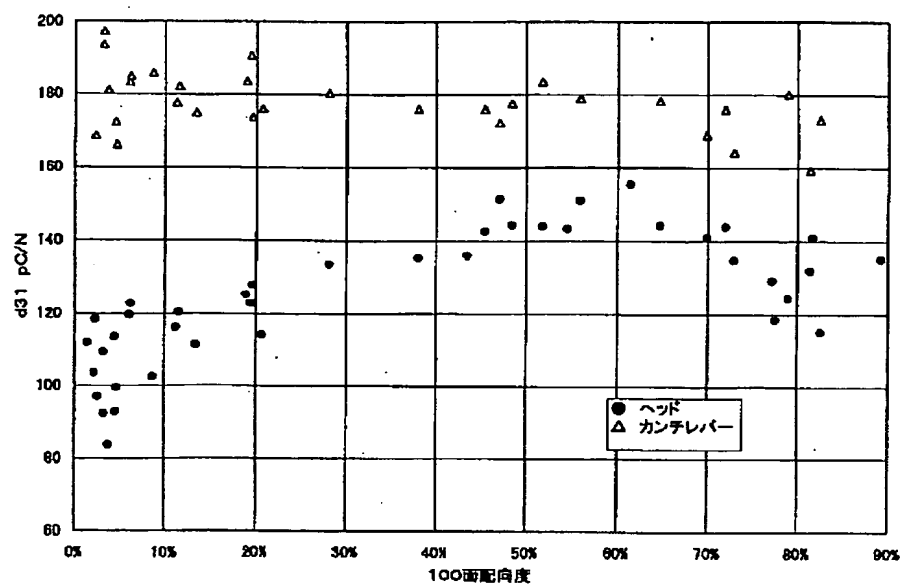
[Drawing 6]



[Drawing 7]



[Drawing 8]



[Translation done.]

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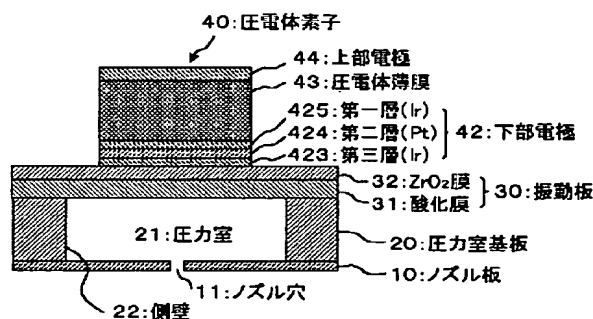
GA01

(54)【発明の名称】 圧電体素子、インクジェット式記録ヘッド、プリンタ、及び圧電体素子の製造方法

(57)【要約】

【課題】 安定した高い圧電特性を備えた圧電体素子およびこれを用いたインクジェット式記録ヘッド、プリンタを提供する。

【解決手段】 ZrO_2 膜32上に、下部電極42(Irを含む第三層423、Ptを含む第二層424、Irを含む第一層425)、4nm以上6nm以下のTi層、圧電体薄膜43、および上部電極44、を順次積層してなり、X線回折広角法により測定した圧電体膜43の100面配向度が40%以上70%以下、110面配向度が10%以下、111面配向度が残部である。この場合、下部電極第二層424の厚さが下部電極42全体の厚さに対して30%以上50%以下である。



【特許請求の範囲】

【請求項 1】 ZrO_2 膜上に形成された下部電極と、該下部電極上に形成された圧電体膜と、該圧電体膜上に形成された上部電極とを備えた圧電体素子であって、前記圧電体膜は、X線回折広角法により測定した 100 面配向度が 40%以上 70%以下であることを特徴とする圧電体素子。

【請求項 2】 請求項 1 に記載の圧電体素子であって、前記圧電体膜は、X線回折広角法により測定した 110 面配向度が 10%以下、111 面配向度が残部であるこ

【請求項 3】 請求項 1 に記載の圧電体素子であって、前記下部電極は、最上層に位置し Ir を含む第一層と、次層に位置し Pt を含む第二層とを少なくとも備え、かつ、該第二層の厚さが下部電極全体の厚さに対して 30%以上 50%以下であり、前記下部電極上に厚さ 4 nm 以上 6 nm 以下の Ti 層を形成し、該 Ti 層上に圧電体膜を形成したことを特徴とする圧電体素子。

【請求項 4】 請求項 3 に記載の圧電体素子であって、前記下部電極は、前記第二層の次層であって前記下部電極の最下層に位置し且つ Ir を含む第三層を備えたこ

【請求項 5】 請求項 3 に記載の圧電体素子であって、前記下部電極のうち、Pt を含む前記第二層が最下層であることを特徴とする圧電体素子。

【請求項 6】 請求項 1 に記載の圧電体素子であって、前記下部電極は、最上層に位置し Pt を含む第一層と、次層に位置し Ir を含む第二層とを少なくとも備え、かつ、該第一層の厚さが下部電極全体の厚さに対して 20%以上 40%以下であり、前記下部電極上に厚さ 4 nm 以上 6 nm 以下の Ti 層を形成し、該 Ti 層上に圧電体膜を形成したことを特徴とする圧電体素子。

【請求項 7】 請求項 6 に記載の圧電体素子であって、前記下部電極のうち、Ir を含む前記第二層が最下層であることを特徴とする圧電体素子。

【請求項 8】 請求項 1 ないし請求項 7 のいずれかに記載の圧電体素子が、該圧電体素子の設置面である振動板上に圧電アクチュエータとして設けられていることを特徴とするインクジェット式記録ヘッド。

【請求項 9】 請求項 8 に記載のインクジェット式記録ヘッドを印字手段として備えていることを特徴とするプリンタ。

【請求項 10】 基板上に、 ZrO_2 膜を形成する工程と、該 ZrO_2 膜上に下部電極を形成する工程と、該下部電極上に厚さ 4 nm 以上 6 nm 以下の Ti 層を形成する工程と、該 Ti 層上に圧電体前駆体膜を形成する工程と、

焼成工程と、を備える圧電体素子の製造方法であって、前記下部電極は、最上層に位置し Ir を含む第一層と、次層に位置し Pt を含む第二層とを少なくとも備え、かつ、該第二層の厚さが下部電極全体の厚さに対して 30%以上 50%以下であり、前記下部電極を形成する工程は、Pt を含む前記第二層を形成する工程と、該第二層上に Ir を含む前記第一層を形成する工程とを少なくとも備える、ことを特徴とする圧電体素子の製造方法。

【請求項 11】 基板上に、 ZrO_2 膜を形成する工程と、該 ZrO_2 膜上に下部電極を形成する工程と、該下部電極上に厚さ 4 nm 以上 6 nm 以下の Ti 層を形成する工程と、該 Ti 層上に圧電体前駆体膜を形成する工程と、焼成工程と、を備える圧電体素子の製造方法であって、前記下部電極は、最上層に位置し Pt を含む第一層と、次層に位置し Ir を含む第二層とを少なくとも備え、かつ、該第一層の厚さが下部電極全体の厚さに対して 20%以上 40%以下であり、前記下部電極を形成する工程は、Ir を含む前記第二層を形成する工程と、該第二層上に Pt を含む前記第一層を形成する工程とを少なくとも備える、ことを特徴とする圧電体素子の製造方法。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、電気機械変換機能を有する圧電体素子に係り、特に、インクジェット式記録ヘッドに用いた際に、優れた圧電特性が得られる圧電体素子、インクジェット式記録ヘッド、プリンタおよび圧電体素子の製造方法に関する。

【0002】

【従来の技術】インクジェット式記録ヘッドは、プリンタのインク吐出の駆動源として圧電体素子を用いる。この圧電体素子は、一般的に、圧電体薄膜とこれを挟んで配置される上部電極および下部電極とを備えて構成される。

【0003】従来、ジルコン酸チタン酸鉛 (PZT) からなる薄膜の結晶構造を規定したり、下部電極上に Ti 核を形成させることにより、特性改善を図った圧電体素子が開発されている。たとえば、特開平 10-81016 号公報には、菱面体晶系の結晶構造を備えかつ所定の配向度を備えた PZT 薄膜が開示されている。また、特開平 8-335676 号公報には、Ir の下部電極上にチタン核を形成した圧電体素子が開示されている。

【0004】しかし、従来の圧電体素子では、圧電体薄膜の所定の配向度を安定して再現性良く得ることが困難であるという問題があった。このような圧電体素子は、

安定した高い圧電特性を得ることが難しく、インクジェット式記録ヘッドないしはプリンタの印字性能を十分に得られない要因となっている。

【0005】

【発明が解決しようとする課題】本発明の目的は、上記問題点を解消して、圧電体薄膜の所定の配向度を安定して再現性良く得ることにより、安定した高い圧電特性を備えた圧電体素子およびこれを用いたインクジェット式記録ヘッド、プリンタ並びに圧電体素子の製造方法を提供することにある。

【0006】

【課題を解決するための手段】本発明の圧電体素子は、 ZrO_2 膜上に形成された下部電極と、該下部電極上に形成された圧電体膜と、該圧電体膜上に形成された上部電極とを備えた圧電体素子であって、前記圧電体膜は、X線回折広角法により測定した100面配向度が40%以上70%以下であることを特徴とする。

【0007】また、110面配向度が10%以下、111面配向度が残部であることが好ましい。

【0008】特に、前記下部電極は、

①最上層に位置しIrを含む第一層と、次層に位置しPtを含む第二層とを少なくとも備え、かつ、該第二層の厚さが下部電極全体の厚さに対して30%以上50%以下であり、前記下部電極上に厚さ4nm以上6nm以下のTi層を形成し、該Ti層上に圧電体膜を形成したものである。また、

①-1前記第二層の次層であって前記下部電極の最下層に位置し且つIrを含む第三層を備えていてもよく、

①-2前記下部電極のうち、Ptを含む前記第二層が最下層であってもよい。

【0009】また、前記下部電極は、

②最上層に位置しPtを含む第一層と、次層に位置しIrを含む第二層とを少なくとも備え、かつ、該第一層の厚さが下部電極全体の厚さに対して20%以上40%以下であり、前記下部電極上に厚さ4nm以上6nm以下のTi核の層を形成し、該Ti層上に圧電体膜を形成したことを特徴とするものである。また、

②-1前記下部電極のうち、Irを含む前記第二層が最下層であってもよい。

【0010】また、本発明は、上記した圧電体素子が設置面である振動板上に圧電アクチュエータとして設けられていることを特徴とするインクジェット式記録ヘッドである。

【0011】また、本発明は、このインクジェット式記録ヘッドを印字手段として備えていることを特徴とするプリンタである。

【0012】さらに、本発明は、基板上に、 ZrO_2 膜を形成する工程と、該 ZrO_2 膜上に下部電極を形成する工程と、該下部電極上に厚さ4nm以上6nm以下のTi核の層を形成する工程と、該Ti層上に圧電体前駆

体膜を形成する工程と、焼成工程と、を備える圧電体素子の製造方法であって、

①前記下部電極は、最上層に位置しIrを含む第一層と、次層に位置しPtを含む第二層とを少なくとも備え、かつ、該第二層の厚さが下部電極全体の厚さに対して30%以上50%以下であり、前記下部電極を形成する工程は、Ptを含む前記第二層を形成する工程と、該第二層上にIrを含む前記第一層を形成する工程とを少なくとも備えるか、または、

②前記下部電極は、最上層に位置しPtを含む第一層と、次層に位置しIrを含む第二層とを少なくとも備え、かつ、該第一層の厚さが下部電極全体の厚さに対して20%以上40%以下であり、前記下部電極を形成する工程は、Irを含む前記第二層を形成する工程と、該第二層上にPtを含む前記第一層を形成する工程とを少なくとも備えることを特徴とするものである。

【0013】

【発明の実施の形態】(原理説明)図9に、 ZrO_2 膜上にIr層/Pt層/Ir層の順で積層された下部電極と、Ti核とを形成し、更に圧電体前駆体膜を形成して結晶化させた圧電体素子について、圧電体薄膜の100面配向度とTi核の厚さとの関係を測定した図を示す。図9において、符号(ア)は、Ptを含む下部電極第二層の厚さが下部電極全体の厚さに対して10%程度の場合を示す。この場合には、Ti核の厚さが4nm以上6nm以下では100面配向度を約90%まで高めることが可能である。しかし、100面配向度をこれと異なる値に調整しようとする場合、Ti核の厚さの変化に対する100面配向度の変動が大きすぎ、所望の100面配向度を安定して再現性良く得ることができない。

【0014】これに対して図9の符号(イ)は、Ptを含む下部電極第二層の厚さの下部電極全体の厚さに対する比率を上記(ア)の場合より増加させた場合を示す。この場合には、Ptの影響を受けて圧電体薄膜の111面配向度が上昇し、100面配向度が上記(ア)の場合より低くなるとともに、Ti核の厚さが4nm以上6nm以下において、100面配向度が安定した値を示している。

【0015】このように、Ti核の厚さを4~6nmとするとともに、下部電極全体の厚さに対するPt層の厚さの割合を調節することにより、100面配向度(100面配向度と111面配向度との比率)を所望の割合に再現性良く合わせ込むことが可能となる。

【0016】以下、本発明の好適な実施の形態を、図面を参照しながら説明する。

【0017】(実施形態1)図1は、本実施形態におけるインクジェット式記録ヘッドの圧電体素子部分を拡大した層構造断面図である。

【0018】図1に示すように、圧電体素子40は、酸化膜31上に ZrO_2 膜32、下部電極42、圧電体薄

膜43および上部電極44を順次積層して構成されている。

【0019】酸化膜31は、例えば厚さ220 μ mの単結晶シリコンからなる圧力室基板20上に形成する。好適には、酸化ケイ素(SiO₂)からなる膜を1.0 μ mの厚さに形成して得る。

【0020】ZrO₂膜32は、弾性を備える層であって、酸化膜31と一体となって振動板30を構成している。このZrO₂膜32は、弾性を与える機能を備えるため、好ましくは、200nm以上800nm以下の厚み10を有する。

【0021】ZrO₂膜32と下部電極42の間には、双方の層を密着するような金属、好ましくは、チタンまたはクロムからなる密着層(図示しない)を設けてもよい。密着層は、圧電体素子の設置面への密着性が良くするために形成するものであり、当該密着性が確保できる場合には形成しなくてもよい。また、密着層を設ける場合は、最低限の密着性が確保できるようにするため、好ましくは、10nm以上の厚みとする。

【0022】下部電極42は、最下層に位置しIrを含む第三層423と、下部電極42の厚さに対して30%以上50%以下の厚さであって、Ptを含む第二層424と、最上層に位置しIrを含む第一層425とから構成されている。下部電極42の全体の厚みは特に制限はなく、例えば100nmとする。なお、焼成前における密着層の厚みをd0、第三層423の厚みをd1、第二層の厚みをd2、第一層の厚みをd3、焼成後の下部電極全体の厚みをdTとしたとき、 $dT = 3.6 \times d0 + 2.4 \times d1 + 0.8 \times d2 + 2.3 \times d3$ の関係が満たされることが好ましい。30

【0023】下部電極42の上にはTi核の層(図示しない)が形成されている。Ti核は、4nm以上6nm以下の厚みである。

【0024】圧電体薄膜43は、通常の圧電性セラミックスの結晶で構成された強誘電体であり、好ましくは、チタン酸ジルコン酸鉛(PZT)等の強誘電性圧電性材料や、これに酸化ニオブ、酸化ニッケルまたは酸化マグネシウム等の金属酸化物を添加したものからなる。圧電体薄膜43の組成は圧電体素子の特性、用途等を考慮して適宜選択する。具体的には、チタン酸鉛(PbTiO₃)、チタン酸ジルコン酸鉛(Pb(Zr, Ti)O₃)、ジルコニウム酸鉛(PbZrO₃)、チタン酸鉛ランタン((Pb, La), TiO₃)、ジルコン酸チタン酸鉛ランタン((Pb, La)(Zr, Ti)O₃)又は、マグネシウムニオブ酸ジルコニウムチタン酸鉛(Pb(Zr, Ti)(Mg, Nb)O₃)等が好適に用いられる。また、チタン酸鉛やジルコニウム酸鉛にニオブ(Nb)を適宜添加することにより、圧電特性に優れた膜を得ることができる。

【0025】圧電体薄膜43は、X線回折広角法により50

測定した100面配向度が40%以上70%以下である。そして、110面配向度は10%以下、111面配向度が残部である。

【0026】圧電体薄膜43の厚みは、製造工程でクラックが発生しない程度に抑え、一方、十分な変位特性を呈する程度に厚くする必要があり、例えば1500nmとする。

【0027】上部電極44は、下部電極42と対になる電極であり、好適には、PtまたはIrにより構成される。上部電極44の厚みは、好適には50nm程度である。

【0028】図4は、本発明のインクジェット式記録ヘッドの主要部の構造を示す斜視図一部断面図である。

【0029】図4に示すように、インクジェット式記録ヘッドは、ノズル板10、圧力室基板20、振動板30および圧電体素子40から構成される。

【0030】圧力室基板20は、圧力室(キャビティ)21、側壁22、リザーバ23および供給口24を備えている。圧力室21は、シリコン等の基板をエッチングすることにより、インクなどを吐出するために貯蔵する空間として形成されたものである。側壁22は、圧力室21を仕切るよう形成されている。リザーバ23は、インクを共通して各圧力室21に充たすための流路となっている。供給口24は、リザーバ23から各圧力室21へインクを導入可能に形成されている。

【0031】ノズル板10は、圧力室基板20に設けられた圧力室21の各々に対応する位置にそのノズル11が配置されるよう、圧力室基板20の一方の面に貼り合わせられている。

【0032】振動板30は、上述したように酸化膜31とZrO₂膜32とを積層して形成されたものである。本発明の圧電体素子40は、当該振動板30の上に圧電アクチュエータとして設けられている。各圧力室21に対応する振動板30上の位置には、それぞれ図1に示す層構造を備えた圧電体素子40が設けられている。振動板30には、インクタンクロ35が設けられて、図示しないインクタンクに貯蔵されているインクを圧力室基板20内部に供給可能になっている。

【0033】ノズル板10および振動板30が設けられた圧力室基板20は、さらに図示しない筐体に収められてインクジェット式記録ヘッドを構成している。

【0034】上記構成において、圧電体素子40の下部電極42と上部電極44との間に電圧が印加されて圧電体素子40が歪むとその歪みに対応して振動板30が変形する。その変形により圧力室21内のインクに圧力が加えられ、ノズル11からインクの液滴が吐出するようになっている。

【0035】図5に本実施形態のプリンタ100の構造を説明する斜視図を示す。図5に示すように、プリンタ100は、プリンタ本体2に、印字手段である本発明の

インクジェット式記録ヘッド1、トレイ3、排出口4、給紙機構6、制御回路8および操作パネル9等が設けられている。

【0036】トレイ3は、印字前の用紙5を給紙機構6に供給可能に構成されている。制御回路8は、操作パネル9からの制御または外部から供給される印字情報に基づいて、用紙5の搬送を給紙機構6に行わせる給紙信号S_dや印字をインクジェット式記録ヘッド1に行わせる印字信号S_hを出力するようになっている。給紙機構6は、用紙5を取り込むローラ601と602およびそれらを駆動するモータ600等で構成され、給紙信号S_dに基いて用紙5を本体2内に取り込むことが可能になっている。インクジェット式記録ヘッド1は、給紙機構6により供給された用紙5の上を横切って移動可能に構成され、制御回路8から印字信号S_hが供給されると、圧電体素子40が変形することによりインクが吐出され用紙5上に印字することが可能になっている。排出口4は、印字が終了した用紙5を排出可能な出口となっている。

【0037】（実施形態2）図2は、本発明の第2の実施形態におけるインクジェット式記録ヘッドの圧電体素子部分を拡大した層構造断面図である。

【0038】本実施形態では、下部電極42は、下部電極42の厚さに対して30%以上50%以下の厚さであって、Ptを含む第二層（最下層）426と、Irを含む第一層（最上層）427とから構成されている点が、上記実施形態1と異なっている。

【0039】（実施形態3）図3は、本発明の第3の実施形態におけるインクジェット式記録ヘッドの圧電体素子部分を拡大した層構造断面図である。

【0040】本実施形態では、下部電極42は、Irを含む第二層（最下層）428と、下部電極42の厚さに対して20%以上40%以下の厚さであって、Ptを含む第一層（最上層）429とから構成されている点が、上記実施形態1と異なっている。

【0041】（製造方法）次に、本発明の圧電体素子の製造方法を説明する。図6及び図7は、本発明の圧電体素子及びインクジェット式記録ヘッドの製造方法を示す断面模式図である。

【0042】酸化膜形成工程（S1）

この工程は、酸素あるいは水蒸気を含む酸化性雰囲気中で高温処理し、酸化珪素（SiO₂）からなる酸化膜31を形成する工程である。この工程には通常用いる熱酸化法その他、CVD法を使用することもできる。

【0043】ZrO₂膜を形成する工程（S2）

圧力室基板20上の酸化膜31の上に、ZrO₂膜32を形成する工程である。このZrO₂膜32は、スパッタ法または真空蒸着法等によりZrの層を形成したものを酸素雰囲気中で高温処理して得られる。

【0044】下部電極を形成する工程（S3）

実施形態1に係る下部電極にあつては、ZrO₂膜32上に、Irを含む第三層423を形成する工程と、該第三層上に、下部電極42の厚さに対して30%以上50%以下の厚さであつて、Ptを含む第二層424を形成する工程と、該第二層上にIrを含む第一層425を形成する工程とからなる。

【0045】実施形態2に係る下部電極にあつては、ZrO₂膜32上に、下部電極42の厚さに対して30%以上50%以下の厚さであつて、Ptを含む第二層426を形成する工程と、該第二層上に、Irを含む第一層424を形成する工程とからなる。

【0046】実施形態3に係る下部電極にあつては、ZrO₂膜32上に、Irを含む第二層428を形成する工程と、該第二層上に、下部電極42の厚さに対して20%以上40%以下の厚さであつて、Ptを含む第一層429を形成する工程とからなる。

【0047】各層423～429は、それぞれIrまたはPtをZrO₂膜32上に、スパッタ法等で附着させて形成する。なお、下部電極42の形成に先立ち、チタン又はクロムからなる密着層（図示せず）をスパッタ法又は真空蒸着法により形成しても良い。

【0048】Ti核（層）を形成する工程

この工程は、スパッタ法等により、下部電極42上にチタン結晶（図示せず）を島状に形成する工程である。Ti核（層）を形成するのは、チタン結晶を核としてPZTを成長させることにより、結晶成長が下部電極側から起こり、緻密で柱状の結晶が得られるからである。

【0049】圧電体前駆体膜を形成する工程（S4）

この工程は、ゾル・ゲル法により、圧電体前駆体膜43'を形成する工程である。

【0050】まず、有機金属アルコキシド溶液からなるゾルをスピコート等の塗布法によりTi核上に塗布する。次いで、一定温度で一定時間乾燥させ、溶媒を蒸発させる。乾燥後、さらに大気雰囲気下において所定の高温で一定時間脱脂し、金属に配位している有機の配位子を熱分解させ、金属酸化物とする。この塗布、乾燥、脱脂の各工程を所定回数、例えば4回以上繰り返して4層以上の圧電体前駆体膜を積層する。これらの乾燥と脱脂処理により、溶液中の金属アルコキシドと酢酸塩とは配位子の熱分解を経て金属、酸素、金属のネットワークを形成する。

【0051】焼成工程（S5）

圧電体前駆体膜43'の形成後、焼成して、圧電体前駆体膜を結晶化させる工程である。この焼成により、圧電体前駆体膜43'は、アモルファス状態の前駆体からペロブスカイト結晶構造が形成され、電気機械変換作用を示す薄膜に変化し、X線回折広角法により測定した100面配向度が40%以上70%以下の圧電体薄膜となる。

【0052】上部電極形成工程（S6）

最後に、圧電体薄膜 43 上に、電子ビーム蒸着法またはスパッタ法により上部電極 44 を形成する。

【0053】以上の工程で得られた、圧電性素子 40 を、使用箇所に適した形状にエッチングして整形し上下電極間に電圧を印加可能に製造すれば、本発明の圧電体素子として動作させることが可能である。

【0054】得られた圧電性素子 40 を、インクジェット式記録ヘッドに適合するようにエッチングして、圧電体素子としての形状に成形する工程について、図 7 に基いて、以下に説明する。

【0055】圧電体素子成形工程 (S7)

まず、圧電体素子 40 を、各圧力室 21 に適合させた形状にマスクし、その周囲をエッチングする。具体的には、まずスピナー法、スプレー法等の方法を用いて均一な厚さのレジスト材料を上部電極上に塗布する。次いで、マスクを圧電体素子の形状に形成してから露光・現像して、レジストパターンを上部電極 44 上に形成する。これに通常用いるイオンミリングまたはドライエッチング法等を適用して、上部電極 44、圧電体薄膜 43、下部電極 42 をエッチング除去し、各圧電体素子 40 を成形する。

【0056】圧力室形成工程 (S8)

次に、圧電体素子 40 が形成された圧力室基板 20 の他方の面に、異方性エッチングまたは平行平板型反応性イオンエッチング等の活性気体を用いた異方性エッチングを施し、圧力室 21 を形成する。エッチングされずに残された部分が側壁 22 になる。

【0057】ノズル板貼り合わせ工程 (S9) 最後に、エッチング後の圧力室基板 20 にノズル板 10 を接着剤で貼り合わせる。貼り合わせのときに各ノズル 11 が圧力室 21 各々の空間に配置されるよう位置合わせする。ノズル板 10 が貼り合わせられた圧力室基板 20 を図示しない筐体に取り付け、インクジェット式記録ヘッド 1 を完成させる。

【0058】(実施例) 上記実施形態 1 の製造方法による圧電体素子を、下部電極全体の厚さに対する Pt 層の厚さの比率を種々変えて幾つか製造するとともに、比較例として、上記実施形態で示した比率以外の比率によっても圧電体素子を幾つか製造した。

【0059】図 8 に、その結果得られた圧電体素子について、100 面配向度と圧電定数 d_{31} との関係を測定した図を示す。特に圧電定数 d_{31} は、高周波 (14 kHz、インクジェットヘッドを用いて測定) および低周波 (DC 駆動、カンチレバーを用いて測定) の両者において測定している。図 8 において、100 面配向度が小さいときは、111 面配向度が大きいことを示している。

【0060】図 8 に示されるように、低周波駆動では 111 面配向度が高いほど圧電乗数 d_{31} が高いが、インクジェットヘッドに使用されるような高周波駆動では、

100 面配向度が 40% 以上 70% 以下のときに、好適な圧電特性が得られることがわかる。また、このような配向度を示す圧電体素子が製造されたのは、下部電極全体の厚さに対する Pt 層の厚さが 30~50% の場合であった。

【0061】なお、圧電定数 d_{31} の測定は、電圧印加時の変位から求めた。また、本願にいう「100 面配向度」とは、X 線回折広角法において CuK α 線を用いたときの XYZ 面に対応するピーク (2θ) の回折強度を I (XYZ) としたとき、I (100) の I (100) と I (110) と I (111) との和に対する比率を意味する。

【0062】(その他の変形例) 本発明は、上記実施形態によらず種々に変形して適応することが可能である。例えば、本発明で製造した圧電体素子の上記インクジェット式記録ヘッドの圧電体素子のみならず、不揮発性半導体記憶装置、薄膜コンデンサ、パイロ電気検出器、センサ、表面弾性波光学導波管、光学記憶装置、空間光変調器、ダイオードレーザ用周波数二倍器等のような強誘電体装置、誘電体装置、パイロ電気装置、圧電装置、および電気光学装置の製造に適応することができる。

【0063】

【発明の効果】本発明によれば、圧電体薄膜の 100 面配向度を安定して再現性良く得ることができる。ひいては、圧電体薄膜の 100 面配向度と 111 面配向度との比率を再現性良く得ることができる。これにより、高周波および低周波のいずれにおいても安定した高い圧電特性を備えた圧電体素子およびこれを用いたインクジェット式記録ヘッド、プリンタ並びに圧電体素子の製造方法を提供することができる。

【図面の簡単な説明】

【図 1】 実施形態 1 の圧電体素子の断面図

【図 2】 実施形態 2 の圧電体素子の断面図

【図 3】 実施形態 3 の圧電体素子の断面図

【図 4】 インクジェット式記録ヘッドの主要部の構造を示す斜視図一部断面図

【図 5】 本発明のインクジェット式記録ヘッドを使用したプリンタの構造を示す斜視図

【図 6】 本発明のインクジェット式記録ヘッドの製造方法を示す断面模式図

【図 7】 本発明のインクジェット式記録ヘッドの製造方法を示す断面模式図

【図 8】 100 面配向度と圧電定数 d_{31} との関係を示す図

【図 9】 100 面配向度と Ti 核の厚さとの関係を示す図

【符号の説明】

20 圧力室基板

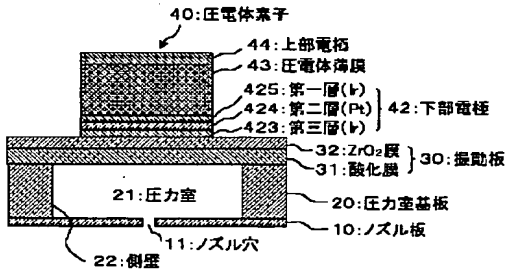
30 振動板

31 酸化膜

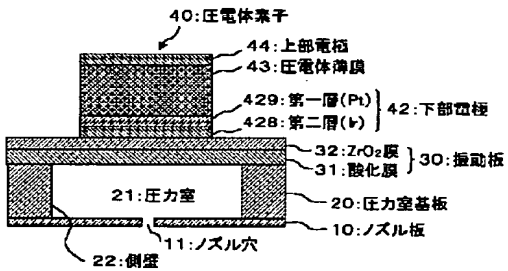
11

- 32 ZrO₂膜
 40 圧電体素子
 42 下部電極
 423 第三層 (Ir)
 424 第二層 (Pt)
 425 第一層 (Ir)

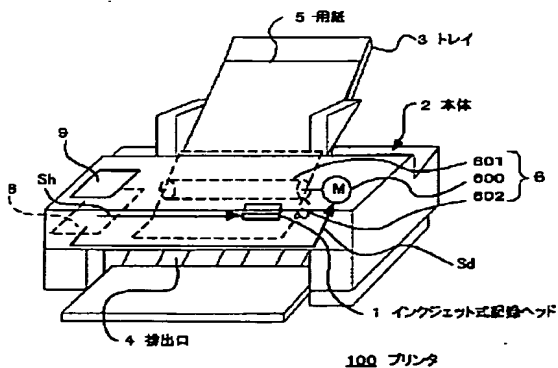
【図1】



【図3】



【図5】

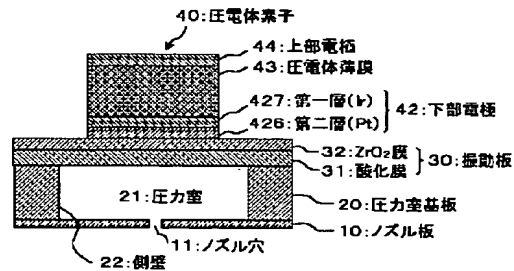


100 プリント

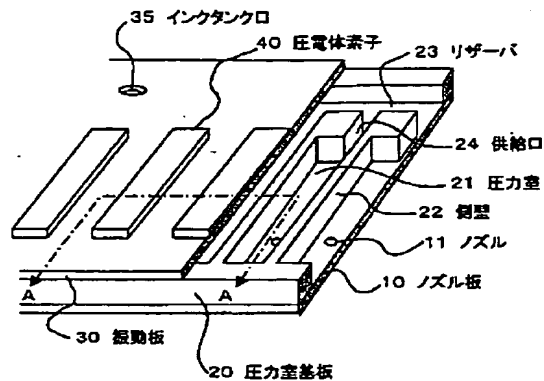
12

- 426 第二層 (Pt)
 427 第一層 (Ir)
 428 第二層 (Ir)
 429 第一層 (Pt)
 43 圧電体薄膜
 44 上部電極

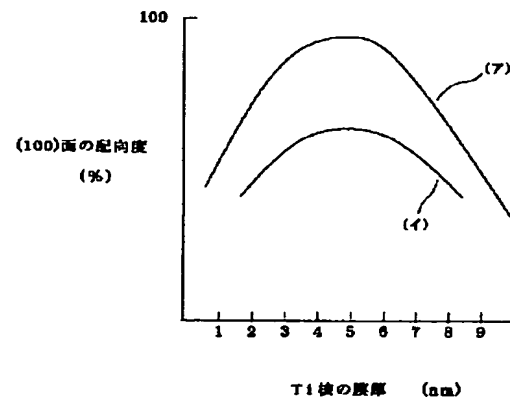
【図2】



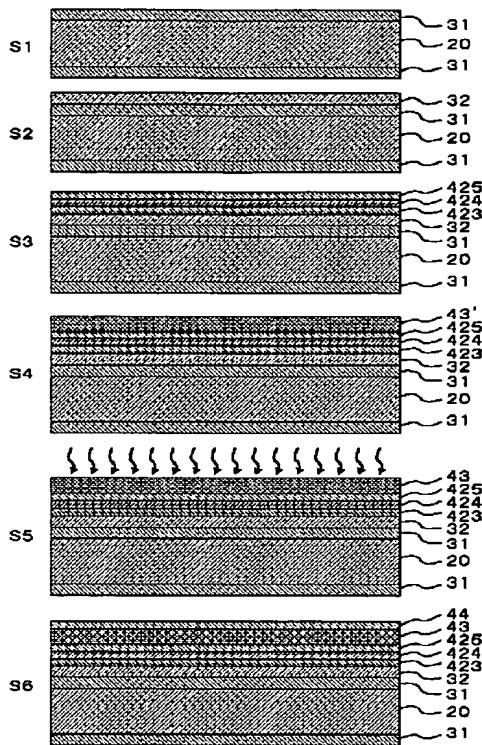
【図4】



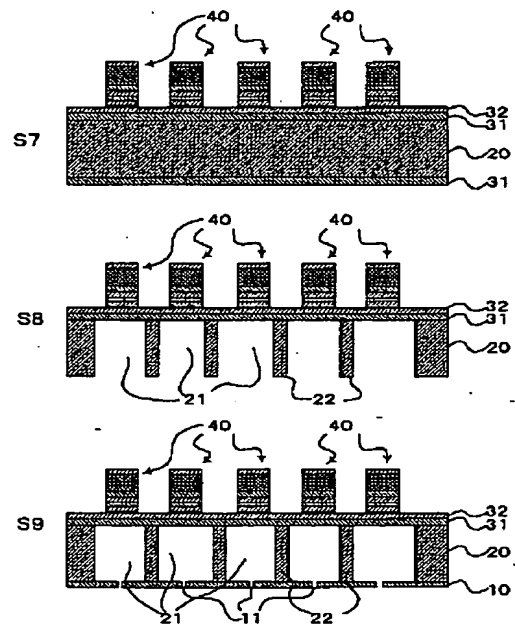
【図9】



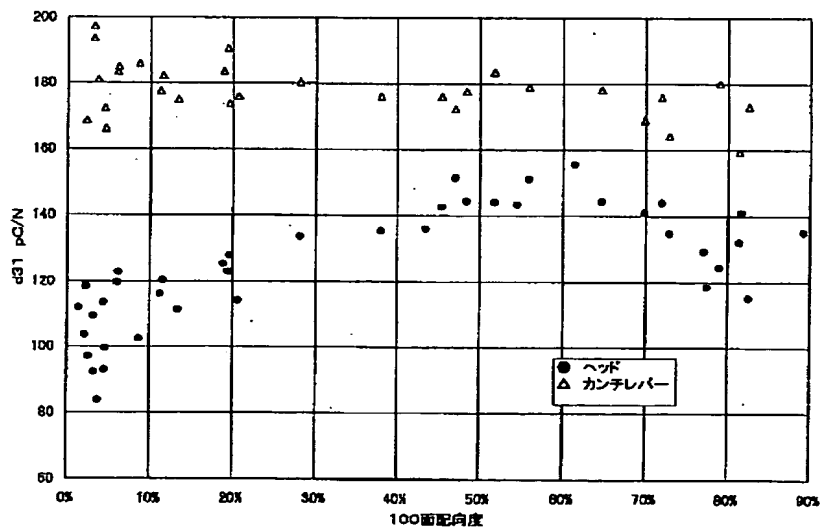
【図6】



【図7】



【図8】



フロントページの続き

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